present time abstracts of about 4,000 papers, all of later date than those noticed in the last German *Jahresbericht*. Our German fellow-workers may therefore, with advantage to themselves, give their support to this English work.

We trust that the appreciation of all interested in chemical science for this most useful work will be so decidedly shown that the Chemical Society will soon have no further anxiety as to the success of their undertaking. The circle of readers appealed to is a very wide one; not only is it an absolute necessity for those who work at Science and those who profess it, but the medical man, the agriculturist, the manufacturer, and the geologist will all find an abundance of matter interesting to their special pursuits.

TODHUNTER'S "MATHEMATICAL THEORIES OF ATTRACTION"

A History of the Mathematical Theories of Attraction and the Figure of the Earth from the time of Newton to that of Laplace. By I. Todhunter, M.A., F.R.S. Two vols. (London: Macmillan, 1874.)

I.

THE late Prof. de Morgan, in his "References for the History of the Mathematical Sciences," divides the written histories into two classes, those which are written on the plan of Montucla, Bossut, &c., in which a general account is framed out of the writer's notes or remembrances of miscellaneous reading; or in that of Delambre, Woodhouse, &c., in which the successive writings of eminent men are examined and described one after the other, so that each chapter or section is a description of the progress of Science in the hands of some one person, and is complete in itself. This latter plan is the one he considers the most favourable to accuracy and the most interesting to students who are desirous of being the critics of the historians, and of amending their works, if need be. The admirable two volumes before us would certainly be placed under this head. As to the utility of such works, our author remarks: "A familiarity with what has been already accomplished or attempted in any subject is conducive to a wise economy of labour; for it may often prevent a writer from investigating afresh what has been already settled; or it may warn him, by the failure of his predecessors, that he should not too lightly undertake a labour of well-recognised difficulty." Mr. Todhunter is no novice in this style of writing; his "History of the Calculus of Variations" appeared in 1861, and at once placed him in the foremost rank of mathematical historians; this work was followed, in 1865, by the "History of the Theory of Probability." The principles upon which these earlier works were written have been adopted in the work under consideration. Experience has improved his already first-rate powers of analysis and of graphic representation of the contents of the works he considers; all that he wants is leisure; possibly a time may come when the University of Cambridge will appoint an historian (or historians) to fill up the painfully patent void which now exists in this department of literature. The acknowledged high merits of his published histories would suggest Mr. Todhunter as a most fitting first occupant of such a chair; the liberality of the syndics of the University Press in defraying the expenses of the printing of this last work affords evidence that the work is appreciated. In his recent volume of "Essays" (p. 151), our author mentions his taste for the history of Mathematics; we heartily hope that the union of such taste and mathematical powers will result in the begetting a numerous progeny all equally comely with, and of as good disposition as, the elder members of the family.

There is one feature in these histories that especially commends them to our own mind, and that is the writer's *candour*. We cannot better express our own views upon this point than by citing the following passage from the late Sydney Smith's writings: "There is nothing more beautiful in science than to hear any man candidly owning his ignorance. It is *so* little the habit of men who cultivate knowledge to do so—they so often have recourse to subterfuge, nonsense, or hypothesis, rather than to a plain manly declaration, either that they themselves do not understand the subject, or that the subject is not understood—that it is really quite refreshing to witness such instances of philosophical candour, and it creates an *immediate* prepossession in favour of the person in whom it is observed." * It is the absence of this candour which has been productive of so much confusion in this subject of mathematical history: the straining after completeness leads to the insertion of second- and third-hand descriptions; the right rule seems to be that of De Morgan and our author, "to give no opinion or account of any book whatever unless such as is derived from personal acquaintance with its contents." Extreme care and painstakingness are manifest throughout without any sign of flagging. Interesting as Mr. Todhunter's histories are, even to the general student, from the many "sidelights' they contain, and which are especially numerous in the present work, they are exceedingly valuable to the special student, on account of the investigations with which they abound. These are not mere reproductions, but they translate, as it were, the old and now almost obsolete language of the earlier writers into the language of modern analysis: thus in § 443 it is remarked of D'Alembert's notation, "It is not very inviting, and he leaves it to explain itself." Some idea of the extent of these investigations may be got from the fact that 475 out of the 1,632 articles are devoted to them.

The author's design is to write the history of the Mathematical Theories of Attraction and of the Figure of the Earth; for this purpose, he says, he has endeavoured to include all the memoirs and works which relate to these subjects. Such has been his diligence in his seven years' research, that we should suppose few books have escaped his notice: certainly none that would materially affect the conclusions he has arrived at. That he would have added a few to his list had he consulted the British Museum library, or had access to that bequeathed by the late Mr. Graves † to University College, we shall probably show in the course of this notice.

Mr. Todhunter shows that the subjects treated of are of no common importance and influence. Researches into both theories have been fertile in yielding new resources for mathematicians: it will suffice to instance the Transformation of Multiple Integrals, the theory of the Potential, and the functions of Laplace. A knowledge of the figure and dimensions of the earth forms the basis of all the numerical results of Astronomy. In § 25 he carefully defines the several terms made use of in the two subjects, equating in a useful way the varying terms employed by different writers.

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* "Conduct of the Understanding."

† We are informed that the liberality of a gentleman who has already been a great benefactor to the College will shortly enable students to get an accurate idea of the treasures contained in the above library.

The foundation of our subject, as all our readers know, is "great Newton's own ethereal self," Newton, "the crown and glory of his race." "The propositions on Attraction are numerous, exact, and beautiful; they reveal his ample mathematical power. The treatment of the figure of the earth is, however, still more striking, inasmuch as the successful solution of a difficult problem in natural philosophy is much rarer than profound researches in abstract mathematics. Newton's solution was not perfect; but it was a bold outline, in the main correct, which succeeding investigators have filled up but have not cancelled. Newton did not demonstrate that an *oblatum* is a possible form of relative equilibrium; but, assuming it to be such, he calculated the ratio of the axes. This assumption may be called Newton's *postulate* with respect to the figure of the earth; the defect thus existing in his process was supplied about 50 years later by Stirling and Clairaut" (§ 44). Newton appears to have arrived at his theorems in attraction in 1685; the first edition of the "Principia" made its appearance in 1687. (De Morgan, in his "Budget of Paradoxes," p. 81, discusses some of the sources of the apple story.)

Mr. Todhunter nowhere takes account of theories maintained before the time of Sir Isaac Newton; these were, for the most part, if not entirely, non-mathematical. A sketch is given in Book III. of Maclaurin's "Account of Sir Isaac Newton's Philosophical Discoveries, in Four Books."* We draw attention to this work because no reference is made to it in the *History*, whereas great part of Books III. and IV. is devoted to the subject of gravitation.

The same reason (for we cannot suppose Mr. Todhunter not to have consulted the work) has possibly induced him to pass over in silence the "Theoricæ Mediceorum Planetarum ex causis Physicis Deductæ"† of Borelli, though Libri, in his Catalogue, states that this writer "uses the principles of the law of Attraction as afterwards promulgated by Sir Isaac Newton."

Hardly a subsequent chapter but contains from one or another writer an acknowledgment of Newton's high powers; we shall here content ourselves with citing only Laplace's warm eulogy:—"Cet admirable ouvrage contient les germes de toutes les grandes découvertes qui ont été faites depuis sur le système du monde;" and further, he says, that the first step thus made by Newton in the theory must appear immense.

Huygens next appears on the scene. Our author (§§ 64, 65) clears up one or two points, more especially the rightful claim to priority of Newton over Huygens; an error which crops up in Barlow's "Mathematical Dictionary" and Svanberg's work on the Lapland Operations.

From § 48 we gather that Mr. Todhunter has not seen the *Opera reliqua*. S'Gravesande, in the preface to vol. ii. (we quote from the edition Amstel, 1728, 4to.), says, "Tractatus de lumine et dissertatio de gravitate quæ ambo scripta gallice dedit auctor, quamvis primum ut ipse in hujus præfatione monet, in linguam latinam vertere sibi proposuerat:" the second is turned into Latin with title "De causâ gravitatis." The *præfatio* occupies pp. 95, 96, *dissertatio* pp. 97-116 with an *additamentum* down to p. 136, and there is a plate: the *De vi centrifugâ* occupies pp. 107-134.

In the *Opuscula postuma* (Lugd. Bat. 1703, 4to.) the treatise *De vi centrifugâ* (pp. 401-428) is founded, if we mistake not, on a different view of gravitation from that assigned to him by Mr. Todhunter in § 50.

Miscellaneous investigations, up to the year 1720, are then considered: Burnet's "Theory of the Earth" is glanced at, Keill's examination of the same, David Gregory's writings (which contribute nothing new), Hermann, Mairan ("Misapplied Mathematics and Misplaced Ingenuity") and the Cassinis, under whose powerful influence doubts arise as to the real shape of the earth, are more fully discussed.

We proceed to Maupertuis, a memoir* by whom is said (§ 128) to be the first example of the adoption of the principle of attraction by French mathematicians. We offer here a collation of the first editions of two of his works with the second editions which Mr. Todhunter discusses (§ 143).

The *avertissement* of 3 pp. in the 1738 edition of the *Examen désintéressé* is not reproduced in the 1741 edition: the 82 pp. of text, as also the 3 pp. of contents, at end, and the one page of errata, appear to be identical with the matter in the later edition. For the *Examen des trois*, &c., the bookseller's *avertissement* (4 pp.) is common to both: the 42 pp. of text appear to be the same; there is no list of errata; the foot-notes of the later edition appear as side-notes in the 1738 copy. The copy we consulted had the two essays bound up together, and is a duodecimo volume.

In the "Philosophical Dissertations on the Uncertainty of Human Knowledge" by the Marquis d'Argens, author of the "Jewish Spy," to which is added M. Maupertuis' "Dissertation upon Gravity,"&c., translated from the French edition, in 2 vols. 1753, with the running title "The Impartial Philosopher," we have the following:—"After M. Maupertuis had examined the Newtonian system and after he had undergone infinite dangers and difficulties in the frozen regions of the North, in verifying a particular part of it, he concludes that we may look upon gravity as a power diffused through all parts of matter by which all its particles attract each other. The concurrence of all the force of matter which composes the earth, attracts and causes bodies to fall towards its surface, keeps the moon in her orb, and produces with regard to the other planets, and with respect to the sun, the like phenomena, always in proportion to the quantity of their force, their direction, and their distance" (pp. 255-263).

Whilst treating of Maupertuis, we think we have seen in the Graves' library the English translation of his "La figure de la terre . . . au cercle polaire," 1738: possibly the extract cited above is taken from it. In § 149 Mr. Todhunter says "Childrey seems" &c.: Joshua Childrey, 1623-1670, was of Magdalen College, Oxford, Archdeacon of Salisbury, 1663. He wrote "Britannia

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* London, 1775. 3rd edit. 8vo.

† Florentiæ, 1666. 4to.

* "Sur les loix de l'attraction:" cf. Bailly.

Baconica, or the Natural Rarieties of England, Scotland, and Wales, according as they are to be found in every Shire." (London, 1660. 8vo.) The passage referred to in the *Examen désintéressé* we presume was taken from the Paris edition (1667. 12mo.), under Carnarvonshire (pp. 244, 245 of the French, pp. 147, 148 of the English edition). In his dedication he writes:—"The calling I have entred into, and the capacity * wherein I have the honour to serve your Lordship, wil (I fear) offend the weake tendernesse of some, who think these deep searches into reason misbecoming a Preacher of Faith, and the contemplation of the works of Nature very impedimentall (if not destructive) to the work of Grace," &c.

Stirling (whom his rival Clairaut calls "one of the greatest geometricians I know in Europe") enunciated without demonstration approximate propositions respecting the magnitude and the direction of the attraction of an homogeneous *oblatum* at its surface and *implicitly* (§ 156) established Newton's *postulate*.

We now proceed to give an account of the original work (not seen by Mr. Todhunter) entitled "Dégré du méridien entre Paris et Amiens." (Paris, 1740.) It has 6 pp. of contents:—lvi. pp. of Part I. in nine chapters, with 3 pp. of plates. Part II. is "Mesure de la terre" par M. l'Abbé Picard, 106 pp., with 10 pp. on Aberration of fixed stars, and 5 pp. of fixed plates. On p. vi. we find, "le dégré comparé à celui que nous avons mesuré au cercle polaire, que nous avons trouvé de 57437, 9 toises donne la terre aplatie vers les pôles; et le rapport de l'Axe au diametre de l'equateur, comme 177 à 178." We had some difficulty in finding the book in the Museum from Mr. Todhunter's description; at last we found it catalogued under the heading Picard.

The Museum copy of the Essay by Celsius (§§ 198, 739, not seen by our author), entitled "De Observationibus," &c., Upsaliæ, 1738, is bound up with several other tractates on our subject, but all the rest partake of the character of the ante-Newtonian writers. Thus Nicolaus Winterberg (1596) heads his chapters—"Rotundam esse (terram) liquido apparet;" "Terram cum aquâ conjunctam σφαιροειδῆν asserimus;" and he further maintains the earth to be the centre of system of universe. We need not give an analysis of Celsius's work here; for this is undoubtedly the original from which the German translation, discussed by Mr. Todhunter, was taken. He styles Newton "vir immortalis," and, deciding against James Cassini, thus ends his ten-page tract—"Spero itaque me jam æquo et candido lectori satis superque ostendisse observationes Cassinianas, tam cœlestes quam terrestres in Gallia præcipue meridionali habitas, adeo incertas esse et inde figura telluris nullo modo deduci queat."

We have now arrived at the period when the question between the Newtonians and Cassinians was decisively settled, and the victory of the *oblates* over the *oblongs* acknowledged even by the Cassinis. This result was brought about by the expedition to Lapland in 1736-37, and won for its ruling spirit, Maupertuis, Voltaire's witty compliment of having "aplati les pôles et les Cassinis."

R. TUCKER

(*To be continued.*)

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* He was chaplain to the "Rt. Hon. my most noble Lord and Master Henry Somerset Lord Herbert, &c."

OUR BOOK SHELF

Elements of Chemistry, Theoretical and Practical. By William Allen Miller, M.D., LL.D. Part II. Inorganic Chemistry. Revised by Herbert McLeod, F.C.S., Professor of Experimental Science, Indian Civil Engineering College, Cooper's Hill. 5th edit., with additions. (London: Longmans, 1874.)

IT will of course be superfluous to say anything in the way of criticism concerning this well-known manual. The death of its lamented author has necessitated the placing of the fifth edition in other hands, and it could not have fallen into better than those of its present editor. The principal changes so far have been a re-arrangement of the articles in accordance with the modern method of study and the removal of certain parts, such as those on gas analysis and the description of certain carbon compounds, to the appendix preparatory to their removal to the third part, to which they more strictly belong.

Some of the constitutional formulæ, now so much in use, have been introduced, and the kind selected have been those used by Frankland in his well-known "Lecture Notes." We are, however, glad to see that these have not been used to the exclusion of the notation adopted in former editions.

Great credit is due to Prof. McLeod for the thorough and conscientious way in which he has performed his task, and the only fault we have to find is that there is occasionally a certain amount of confusion caused by the use of different names for the same body, a fault for which, however, the science itself is largely responsible.

R. J. F.

Zones of Parallel Lines of Elevation in the Earth's Crust. By Angus Ross, sec. and mem. com. N. S. Inst. of Nat. Science. (Halifax, Nova Scotia, 1872.)

HE is a bold man who will predicate that no future discovered fact will disturb even the most widely accepted hypothesis. This being so, all hypotheses being in fact tentative only, and valuable in so far as they enable us to classify and deduce laws from such facts as we know, we ought to welcome every generalisation which groups known facts under some new aspect. In the above pamphlet we have such a generalisation. Whether it will prove to be supported by future discovery, or even whether it can be rigidly applied to explain actual facts will require much close criticism to determine. We can only say that it is ingenious and novel. The author claims to have discovered the method of distribution of the various mountain chains or lines of anticlinal elevation. These he asserts are arranged in parallel lines along certain belts or zones which girdle the earth, each zone following approximately the course of a great circle, and each having for its medial line or axis a line of volcanoes. Of these zones he describes seven, and we may extract one as a type of the rest. "Zone No. 1 on the Rocky Mountain system has its axial line in the volcanic belt extending from the middle Andes, inclusive, across Central America along the Rocky Mountains, Alaska, the Aleutian Islands, Kamtschatka, the Kurile Islands, Japan Islands, Loochoo Islands, Philippine Islands, Palawan, and Borneo. The Islands of Amsterdam and St. Paul, the Kerguelen Islands, the South Sandwich Islands, and South Georgia seem to indicate the completion of the more southerly part of the (approximately) great circle." The author, as we have said, describes seven such zones or belts which intersect one another, and argues that the points of intersection are foci of volcanic energy. He argues also that the great mountain-chains in their direction follow the course of one or other of these zones, and thus describes their arrangement:—"In each zone the proximity and elevation of the anticlinals diminish gradually from the axial line outwards, and if zone No. 1 be considered the most recent,